nominotypical *orion* both exist together. The only region of a certain extent, in which *telephii* seems to exclude, or nearly exclude, the latter, seems to be the south of France, where, according to Oberthür, both sexes are constantly broadly blue, both in the Pyrénées Orientales and in the Alpes Maritimes. Frühstorfer, too, includes females from la Turbie, near Monaco, in his *lariana*, showing this name is a synonym of *telephii*, the Como and the French form evidently being equivalent, even to his mind, but he having overlooked the fact that the latter is perfectly similar to the one of Central Germany, as figured under the name of *telephii* by Esper and by Bergsträsser on his plate 56 (he also figures the nominotypical *orion* from the same county of Hanau on pl. 60) and as figured by Hübner from Austria, under Schiffermüller's name of *battus*, in his figs. 328-30, included, in his text, in the same paragraph as figures 801-2 of *orion* and with the same habitat, just as specimens from Vienna do, as a matter of fact, exhibit this variation from *telephii* to *orion*.

Effects of Radiant Heat on the Development of some Butterflies.

By ORAZIO QUERCI.

In the breeding experiments that we have made in these last few years, we have inquired into the effects of temperature, humidity, atmospheric pressure, wind and alimentation on the development of some Lepidoptera. As the results of every experiment since almost none were in accordance with those of the other trials, we suspected that another factor was influencing the larval stages of the insects.

Last summer, while collecting on the Macedonian side of the Olympus Mt., we rented a piece of ground with a source of water, and several kinds or plants for larvae were planted there. By the end of July 1936 the country was barren, while in our field the vegetation was luxuriant; then we put on the plants many eggs of different species of insects.

Having seen that the frail shell of the eggs and pupae preserve the vitality of those living things even when it is hot, we built some shelters, with different sorts of material, in order to note the behaviour of the larvae in the shelters, while the larvae in the open were injured by heat.

When some eggs had hatched and everything was ready for experiments, the Police invited us to leave Greece and to exchange some American gold, although we had duly declared our money before landing in this country. Besides that the Government stated that everybody leaving Greece must pay 20,000 drachms for the visa to the passport; thus we should have been obliged to pay £76 for my wife and I.

We made a petition to H.M. the King of Greece, and we were allowed to remain here keeping our gold; however during that troubled time our expensive experiment was lost. Now we must give up with Entomology and get another job, but before doing that we will summarize what we have observed about the influence of radiant heat on the development of some butterflies. Recently we have learnt that the fatal effects of these rays have been proved by experiments, as a

strong source of radium destroyed the vitality of some caterpillars, and they were killed.

In the *Encyclopaedia Britannica* we read the following words, which have given me the idea—"The rays resemble other specifics, which are beneficial in small, but harmful in large amount, when applied to living things."

Radiant Heat and Eggs.—When heat was intense the eggs hatched in a short time; when heat was moderate the eggs either hatched rapidly, or delayed longer than we expected, or never hatched. At Lisbon (Portugal) the weather was lovely by the end of December, 1932; some *Pieris*, *Pontia*, *Euchloë* and *Colias* emerged in the country, and we took a few mated females which laid many eggs that we kept in a room where the temperature never was below 50°. In January 1933 the radiation became feeble and all those eggs dried inside. On the other hand at Philadelphia, Pa., while the radiant heat was strong in July 1932, some eggs of *Pieris* hatched after a fortnight in a refrigerator at 45° to 50° (*Ent. Rec.*, XLIV. p. 170, 1932).

Radiant Heat and Larvae of Pieridae.—When the larvae hatched and the radiant heat was very strong, they dropped on the ground and died almost at once (*Ent. Rec.*, XLVII. p. 125, 1935). Sometimes the larvae in our broods fed, moulted and pupated at a temperature of 91° (*l.c.*, p. 87) as radiation was moderate; on the other hand they died, even at 89° (*l.c.*, p. 74) if the rays were strong, and when the larvae died at room temperature they collapsed also in the subsoil of a big building, where the temperature never rose above 80°, and in an ice-box at about 60°. Only below 50°, confined in an ice-box, the larvae were not injured by the strong rays.

In our broods the larvae grew well, even at a moderate cold, if radiation was suitable, while they remained inactive until they collapsed if, in spite of the mild weather, the rays were feeble for a long time.

Only those larvae that met with favourable conditions of radiation, heat and food during their short larval stage succeeded in pupating; otherwise they died.

I must record that at Philadelphia some larvae of *Pieris rapae* often formed their pupae in a week, while at Tangier, in Portugal, Spain and Greece they never became mature in less than a fortnight.

Having seen that the larvae of the *Pieridae* almost always died above 90°, and that sometimes they were injured at 60°, we were surprised when at Salonika we saw that in March 1936 many caterpillars fed actively, moulted and pupated rapidly in an incubator at 110° in spite of the little aeration, moderate light and high vapour pressure. In such conditions the larvae rotted only when we fed them with a poor quality of food (*Ent. Rec.* XLVIII. p. 110, 1936).

Last December we took a worn female of *Colias crocea*, which laid many eggs upon a plant of clover. The larvae that hatched were put into an incubator of the University of Salonika, at a temperature of about 100°, and I daily went and set a fresh plant to replace the faded ones. In January 1937, on account of the prevailing influenza epidemic, I was unable to supply those larvae with food, and they remained for ten days in that hot room with dry plants only. When I looked again at the breeding cage I saw that some larvae were still living, and a few

had formed pupae, which produced adults in a few days, while the sun was shining.

I believe that in both experiments, which I have recorded above, the larvae resisted intense heat because the radiation was feeble.

Radiant Heat and Larvae of Papilio.—The larvae of a few species of *Papilio* that we have reared never were injured by a strong radiation. If radiant heat increased while they were feeding they were overcome by stupor, but became active again if a fan was set going near them.

The larvae which started to moult with a suitable amount of radiation succeeded in casting their skins in a short time; on the other hand if the Millikan rays became intense, the moulting larvae remained long dormant and they cast off their skins with difficulty, after radiant heat decreased.

If radiation was suitable, the larvae that had finished feeding hung up at once and in a perfect manner. At a very feeble degree of radiation the mature larvae were overcome by stupor; at a high degree they became excited and afterwards dormant. Often those weakened larvae hung up imperfectly, and sometimes remained on the ground but did not die.

The larvae which had hung up in a short time formed pupae in a few hours, and those *active pupae* emerged in a few days if radiation continued to be suitable. However if radiation either increased or decreased considerably while the active pupae were *nearing their physiological change* they delayed emergenee (*arrested pupae*) until after the environment became settled for several days near the optimum range for the emergence of the pupae of the *Papilio*.

Sometimes the arrested pupae emerged when the climate was lovely, but at other times they did not. I must confess that I am still very far from being able to explain what are the complex causes of the emergence of the pupae.

The mature larvae, that had laid dormant became feeble and even under the most favourable conditions, needed some days to recover and so form *dormant pupae* that never emerged in the same year in which they were formed.

Records about the Emergence of a few Kinds of Pupae.—It is well known that the emergences of every kind of pupa are arrested by cold and scanty radiation. Radiation is the most important factor, as is proved by the fact that, in winter, the pupae rarely emerge even if they are in a hot room. We record that some pupae of *Papilio machaon* and *Zerynthia rumina* emerged in full winter, in our rooms warmed by a stove, at Madrid, Tangier and Salonika. That happened with the combined efforts of heat and radiation; however in winter we never succeeded in producing a premature emergence of *Pieridae*.

The pupae of the *Pieridae* are more or less active, as their larvae die from any sensible fluctuation of the rays. The pupae of *Pieris rapae*, *Pontia protodice*, *P. daplidice*, *Colias eurytheme* and *C. crocens* (which we have handled in America, Europe and Africa) never were arrested by strong radiations. The emergence of some pupae of *Pieris brassicae* was once arrested, at Lisbon, although on that day the temperature never was over 75° (*Ent. Rec.*, XLVIII. p. 38, 1936.) However, the radiant heat was so exceptionally strong that some men and horses were harmed in the City. Those pupae emerged three or four months after. When at Salonika we tried to arrest by heat the pupae of *P.*

brassicae we did not succeed as those experiments were made in March and April, and the radiation was not sufficiently strong.

The pupae of the second brood of *Euchloë belemia* and *E. ausonia* emerged in a few days until the radiation had a moderate strength; otherwise they delayed emergence until the following year, or after two years.

At Philadelphia we reared larvae of *Papilio polyxenes* of the third, fourth and of the last mongrel brood. The active pupae emerged in a few days, except those of the last brood, which were arrested when the temperature fell, in October 1932, but they emerged, in a cabin of the steamer at 75°, both at Boston and near the Azores Islands, while the sun was shining. A few arrested pupae of the third brood emerged at Philadelphia, in mid-August, after the radiant heat had decreased; the other arrested pupae of the third brood produced adults in September together with those of the fourth brood. All the dormant pupae remained. We took them with us, and they emerged in Portugal and Spain from May to July of the following year.

The pupae of *Papilio machaon*, from our broods at Lisbon and Cuenca (Spain) emerged partly in a few days. Some emerged in winter in a warm room at Madrid, and the others at Tangier in the spring of the following year.

At Tangier we reared *P. machaon* from May to December 1934 and obtained pupae of the second, third and fourth brood and of the last mongrel brood. Both active and arrested pupae produced adults in Morocco; the dormant ones were taken with us when we came to Greece. Most of them emerged at Salonika from May to September 1935; the others from May to October 1936.

In Greece we have not been able to rear *P. machaon*, as this species is very scarce here and our African specimens never mated in our cages.

Conclusions.—The various kinds of rays have a different influence over living things according to their degree of intensity, and in accordance with the climate of the place where the plants and animals live.

Man can live in a cold environment until the rays are strong; he does not suffer at a relatively high temperature if the rays are very feeble; he fits well at any intermediate temperature provided that radiation is balanced by the other factors of the climate.

The vital limits of the human kind are wide, and man can endure strong deviations from its optimum range. Only when the rays are either very intense, or very feeble in relationship to the environment, it seems that epidemics spread.

The fertility of the insect is formidable, and if it were not for the "balance in nature," most of them must die in the larval stage when their genitalia are not yet formed. So, the limits of vitality of the insects are reduced, and their eggs, larvae and pupae die at any slight deviation from the suitable range.

I believe that it will be hard to state by figures in any particular case what the suitable range is, as the combinations of the different kinds of rays with the other climate factors are endless, and every species of insect has a different vital range in each of its stages.—Salonika, 20th April, 1937.